SSTD-8070-0081-ELEC Revision D
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National Aeronautics and
Space Administration
John C. Stennis Space Center
Stennis Space Center, MS 39529-6000

COMPLIANCE IS MANDATORY

JOHN C. STENNIS SPACE CENTER
FACILITY ELECTRICAL STANDARD

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Document History Log

Status/ Change/ Revision	Change Date	Originator/ Phone	Description
Basic	12/14/01	Roy Worthy 8-1820	Initial release – supersedes SSC STD 50-008, Revision A, with the following changes: New document number and format per SPG 1400.1; Throughout the document, edits and rewrites for content changes, and English units of measure added in parentheses after metric units; Table of Contents changed to reflect text mods and reorganizations; 2.0 adds, deletes and changes per text references and changes in document numbering; 3.0 retitled and text added for Responsibilities; 4.3 title change 'Guide' to 'Regulations'; 5.1.1-b change allows NASA Technical Monitor to determine data format; 5.1.1-h added new for panel schedule and changed 'field engineer' to 'construction monitor'; 5.2-NOTE delete CFR ref and allow substitutions as approved by the NASA Technical Monitor; 5.3-g delete High-Voltage System Engineer and have requirements specified by the NASA Technical Monitor only; 5.4-a & -b delete refs to NEC tables; 5.6.1 change requirement from # 8 AWG to # 10 AWG; 5.6.2 delete subsection Fire Alarm Circuits and Wiring Color Codes and renumber subsequent subsections; 5.7 delete CFR ref; 5.7-f change # 8 AWG to # 10 AWG, delete 'solid' copper requirement, add 'for circuits over 250V' for spring tension connectors; 5.7-g add for split lug connectors if crimping not possible, add 'first with rubber' to double wrap requirement; 5.7-i delete ref to ANSI C37.20.1; 5.8.1-e delete 'control' and add 'unless approved by NASA Technical Monitor'; 5.8.2-h allow EMT on exterior installations if not subject to extreme weather, mechanical damage or hazardous areas; 5.8.2-i add that pull strings be weather resistant; 5.8.2-k add trace tape requirement; 5.8.3-a complete rewrite delete diameter and metallic tubing requirements; 5.8.3-b delete (Security and Fire Alarm Systems) and renumber all subsequent steps; 5.8.3-e add that pull strings be weather resistant; 5.9-NOTE delete ref to 29CFR1910; 5.9.3 limit copper winding requirement only to dry transformers >75 kVA; 5.9.5 change '2-2.5%' to 'two 2.5%'; 5.9.6-a change non-linear loads from 40% to 25% and change '2-2.5%' to 'two 2.5%'; 5.9.6-b last sentence put first, bold; 5.9.7 delete refs to NPA 70, ANSI/IEEE C2 and 29 CFR 1910; 5.10 Distribution Switchboards moved to 5.12; 5.18 Motors moved to 5.10; 5.11 reorganized and merged with previous sections 5.19 Motor Starters, 5.20 Manual Starter, and 5.21 Motor Control Schematic Wiring Diagram, and subsequent sections appropriately renumbered, with the following changes: 5.10-a delete refs to NEMA Std MG1-12.53 and IEEE 112; 5.10-c, -d, -e add footnote to consult with NASA Technical Monitor for substitutions if motor or power vary from specified ranges; 5.11.1-b apply padlock provision to all devices; 5.11.2-b change copper bus to plated copper bus; 5.11.5 text rearranged; 5.11.2-g delete '(ea.)' in two places; 5.12-h change copper to plated copper for busses rated 225 amps or higher with other bus materials approved by the NASA

			Technical Monitor and neutral bus fully rated; 5.12-l delete refs to ANSI/IEEE C2, NFPA 70, and 29 CFR 1926; 5.12-m add new to use main breakers when required by NEC; 5.13-b change same as in 5.12-h above; 5.13-h delete ref to NEC table; 5.14-d change copper to plated copper for busses rated 225 amps or higher; 5.14-k delete ref to NEC table; 5.14-s change single-phase panel boards from acceptable to unacceptable, unless approved by NASA Technical Monitor; 5.15.1-f change water fountain receptacle requirement from single to GFCI; 5.18-a delete ref to NEC Article 620-51; 5.18-b delete ref to NEMA spec KS1-1975; 5.20-a change NASA Facilities Engineering Division to NASA Technical Monitor; 5.20-c delete breakrooms & corridors, and list restrooms with the exceptions; 5.21-d delete ref to NFPA 101 paragraph 31-1.3.8; 5.21-e add new for auto test and diagnostic routine; 5.23-d delete refs to NEC Articles 645 & 685; 5.21-j add new for battery cell cabinet maintenance; 5.25 FIRE ALARMS delete all 9 subsections, change NOTE to paragraph format and add ref to NASA Std 8719.11; 5.26-a delete ref to NEC Article 250; 5.26-f delete ref to NEC 250-94; 5.26-n delete ref to IEEE Std 81; 5.27-e relax requirement for copper only by add of qualifiers and that all materials must be approved by the NASA Technical Monitor; 5.28-f change '10 pole switches' to '10-pole switches'; Appendix A adds, deletes and changes per text changes and edits.
A	12/29/06	James W. Hughes x 8-2304	Revalidated. Updated references and amended text to reflect proper references. Appendix A additions, deletions, and changes per text edits. Corrected typographical errors throughout document. Added Note in section 5.13 (k). Changed titles for signatures per NASA SSC organization changes.
B	06/12/08	Thomas Rich x 8-3946	NASA organization titles changed per organization change. Global change from NASA Tech Monitor to NASA Project Manager (PM). Administrative changes throughout document. Updated references. Divided section 2. Section 4.3: added reference to NFPA 780 and LPI-175. Section 4.5: added reference to OSHA 29 CFR 1910.147. Section 5.1.1 (f): deleted verbiage stating control equipment shall be date compliant for the year 2000 and beyond and manufacturer's submittal of cert of compliance forwarded to CEF. Section 5.2: deleted 5.2.1, 5.2.2, and 5.2.3. Section 5.3: (a) added verbiage for UL type MV-90 to be minimum, added statement for underground splices; (b) deleted requirement for markers every 200 meters and at each turn for underground ductbanks; (d) deleted option for 200-amp size; (g) changed requirement for wood poles to be approved by NASA PM. Section 5.6: added reference to NFPA 70 110.15 and 230.56. Section 5.6.1 (b): removed "Positive 28 V - Red with white stripe" and "Negative 28 V - Black with white stripe". Section 5.7: (i) deleted "Use No. 14 AWG, 300V stranded copper for all control wiring unless otherwise required"; (j) - added reference to SOI-8080-0007; added (k). Section 5.8.1: added statement to (a); (f) removed minimum requirement for 50% spare capacity for data acquisition raceways; (i) changed verbiage for acceptable ground conductors. Section 5.8.2: (c) added orange stain requirement; (d) deleted reference to "wrapped or coated rigid galvanized steel conduit"; (i) changed requirement for pull strings to be #14 AWG. Section 5.8.3: (e) changed requirement for pull

			strings to be #14 AWG; (i) deleted requirement for the cross-section area of the conductors. Section 5.9.1: deleted reference to SpecsIntact Section. Section 5.9.2: replaced 120/240 V or 277 V with 480/277 V for secondary voltages, deleted reference to SpecsIntact Section. Section 5.9.4 - deleted verbiage and added reference to metering section (5.28). Section 5.11.3 (c) changed requirement from one N.C. and N.O. to two. Section 5.12 - added (n) and (o). Section 5.13: added (c); (h) changed 100' to 150'; (i) changed (6') to (6'-7"); added (o). Section 5.14: (h) changed from orange to orange triangle; (j) changed requirement for maximum distance; (l) changed distance. Section 5.15.1: (e) added reference to NFPA 70; (f) changed "GFCI receptacles" to "GFCI protection"; added (g). Section 5.15.5: changed orange to blue. Section 5.19: added (b); (c) added requirement for remote control/monitoring interface; added (k) and (l). Section 5.20: added (a), (e) added requirement for remote control/monitoring interface. Section 5.23 - added (a). Section 5.24 - added (e). Section 5.26: (b) changed limit of 5 ohms to range of 1-5 ohms; changed maximum of grounding system resistance from 1 ohm to 5 ohms; (f) changed requirement from "No. 12 AWG or larger"; (j) expanded requirement for providing test wells; (k) added reference to 5.26 (d); (n) added qualifying statement to first sentence, changed requirement for single rod electrodes from not exceeding 25 ohms to not exceeding 10, added statement for lightning protection systems resistance to true ground, changed resistance for control grounding systems from 5 ohms to 0.5 ohm maximum, deleted minimum distance requirement; added (o) and (p); (r) expanded to clarify isolation requirements. Section 5.27: (a) changed responsibility from ESD Design Branch to "facility requirements document"; (c) replaced AMCR 385-100 with NASA-STD-8719.12, replaced NSTS 07636 with CxP 70080; added (g), (h), (i), (j), (k), (l), (m), (n), and (o); (p) changed LPI to UL. Section 5.28: (a) added second statement; replaced (c); replaced (e); added (i). Section 5.29 - added verbiage for building automation system.
C	07/26/13	Kelly King x-2682	Five-year review; updated formatting and references; replaced references to SSC STD 50-002, SSC STD 99-006, and SSC STD 99-020 with SSTD-8070-0085-EMCS, SSTD-8070-0004-CONFIG, and SSTD-8070-0083-ELEC, respectively. Deleted note on "Deviations" under Applicability on Page 7. Added Attachment: EMI 09B307-05, E-502.
C-1	3/25/14	Kelly King x-2682	Added Panel Schedule Submittal and Phenolic Label Plate Request forms with new SSC numbers, and SORD 20000-E010, Procedure for Updating CEF Electrical Panel Schedule Database to reference section.
C-2	8/26/15	Carol Wolfram x-1164	Administrative change; correcting 5.0 references to 6.0 references in 6.3-f, 6.8.1-i, 6.11.2-c, 6.14-n, 6.19-a, and Appendix A.1.
C-3	02.16.16	Carol Wolfram x-1164	Administrative change. Replaced "FOSC" with "SACOM" throughout document.

D	4/29/16	Thomas Rich x 8-3946	Format and grammatical changes made. Updated references and acronyms. Revised cover sheet to require approval from NASA SSC Center Operations Design & Construction Project Management Division, with concurrence from NASA SSC Center Operations Directorate Operations and Maintenance Division, NASA SSC Engineering & Test Directorate, and NASA SSC Safety and Mission Assurance. Updated acronyms and references. 6.1.1-b General Requirements: Added requirement for arc flash hazard analyses. 6.1.1-c: Deleted "Ensure that the primary feeder has adequate spare capacity to supply the added load imposed by the proposed project." 6.1.3: Specified 2013 version of Microsoft Project. 6.13.-k and 6.14-m: Revised panelboard description to read as follows: "Panelboards served by uninterrupted power supplies (UPSs) shall be clearly marked with minimum 12.7mm (1/2-inch) high white lettering on black background."

Table of Contents

1.0 PURPOSE

This John C. Stennis Space Center (SSC) standard (SSTD) provides guidelines for the design, construction, modification, and maintenance of electrical systems at SSC.

> **NOTE:** This standard may be supplemented by project requirements from the customer(s) and the National Aeronautics and Space Administration (NASA) SSC Center Operations Directorate as well as the Project Management and Operations and Maintenance divisions. Engineering and Test Directorate (E&TD) electrical requirements are provided in SREF-8060-0001.

2.0 APPLICABILITY

This SSTD is applicable to:

a. SSC and its contractors in regard to electrical systems including but not limited to: Power generation and distribution, lighting, uninterruptible power sources, security, fire alarm, lightning protection, grounding, bonding, metering, DC power, and communications networks.

b. The customers for electrical design and construction, including but not limited to: Facility occupants, system users, NASA SSC E&TD, the maintenance organization, and the funding organization.

c. All organizations and/or individuals responsible for facilities design and construction and/or the use of electricity at SSC. They shall incorporate the information outlined in this SSTD into their designs and electrical installations.

3.0 REFERENCED AND APPLICABLE DOCUMENTS

All references are assumed to be the latest version unless otherwise indicated.

42 U.S.C. 6834	*Federal Building Energy Efficiency Standards*
ASTM C1089	*Standard Specification for Spun Cast Pre-stressed Concrete Poles*
IEEE 81	*Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System*
IEEE 112	*Standard Test Procedure for Polyphase Induction Motors and Generators*
IEEE 142	*IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems*
IEEE 386	*Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V*

IEEE C2	*National Electrical Safety Code*
IEEE C37.20.1	*Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear*
IEEE C57	*Distribution, Power, and Regulating Transformers*
IEEE C57.110	*Recommended Practice for Establishing Liquid-Filled and Dry-Type Transformer Capability When Supplying Nonsinusoidal Load Currents*
IEEE C57.12.20	*Standard for Overhead Type Distribution Transformers, 500 kVA and Smaller: High Voltage, 34 500 V and Below; Low Voltage, 7970/13 800Y V and Below*
IEEE C62.11	*Standard for Metal-Oxide Surge Arresters for AC Power Circuits*
LPI-175	*Standard for the Design-Installation-Inspection of Lightning Protection Systems*
MIL-HDBK-419A	*Military Handbook: Grounding, Bonding and Shielding for Electronic Equipments and Facilities*
NASA-STD-8719.11	*Safety Standard for Fire Protection*
NASA-STD-8719.12	*Standard for Explosives, Propellants, and Pyrotechnics*
NEC Article 250	*Grounding and Bonding*
NEC Article 384	*Switchboards and Panelboards*
NEC Article 500	*Hazardous (Classified) Locations*
NEC Article 645	*Information Technology Equipment*
NEC Article 685	*Integrated Electrical Systems*
NEMA Standard MG1-12.53 (a), (b)	Motors and Generators
NFPA 70	*National Electrical Code*
NFPA 70 110.15	*High-Leg Marking*
NFPA 70 230.56	*Service Conductor with the Higher Voltage to Ground*
NFPA 70E	*Handbook for Electrical Safety in the Workplace*
NFPA 72	*National Fire Alarm and Signaling Code*
NFPA 101	*Life Safety Code*
NFPA 780	*Standard for the Installation of Lightning Protection Systems*
NPR 8715.3	*NASA General Safety Program Requirements*
NPR 8820.2	*Facility Project Requirements*
NSTS 07636	*Lighting Protection, Test and Analysis Requirements*
OSHA 29 CFR 1910	*Occupational Safety and Health Standards*
OSHA 29 CFR 1910.147	*Control of Hazardous Energy (Lockout/Tagout)*
OSHA 29 CFR 1910.269	*Electric Power Generations, Transmission, and Distribution*
OSHA 29 CFR 1926	*Safety and Health Regulations for Construction*
SREF-8060-0001	*NASA SSC E&TD Electrical Systems Design and Installation Guide for Measurement, Monitor, and Control Systems (MM&CS)*
SCWI-8500-0026-ENV	NASA SSC Environmental Resources Document
SOI-8080-0007	*SSC Test Site Drawings*
SORD 20000-E010	Procedure for Updating CEF Electrical Panel Schedule Database

SpecsIntact	*SSC Guide Construction Specifications*
SPR 1400.1	*Document Preparation, Numbering and Management*
SPR 1440.1	*Records Management Program Requirements*
SPR 8715.1	*Safety and Health Procedural Requirements*
SSC Form 886	*Panel Schedule Submittal*
SSC Form 903	*Phenolic Label Plate Request*
SSTD-8070-0001-CONFIG	*Facilities Engineering Documentation Standard*
SSTD-8070-0002-CONFIG	*SSC Facilities Drafting Manual*
SSTD-8070-0004-CONFIG	*Preparation of Construction Specifications*
SSTD 8070-0005-CONFIG	*Preparation, Review, Approval and Release of SSC Standards (SSTDs)*
SSTD-8070-0083-ELEC	*Standard for the 13.8 kV Distribution System*
SSTD-8070-0085-EMCS	*Lighting Design, Operation and Maintenance Standard for Energy Conservation*
SSTD-8070-0138-ELEC	*SSC Arc Flash Standard*
UL 96A	*Installation Requirements for Lightning Protection Systems*
UL 1561	*Safety Dry-Type General Purpose and Power Transformers*

4.0 RESPONSIBILITIES

a. Users of this SSTD shall comply with its requirements, ensure use of the correct version of this SSTD and the documents it references, and inform the appropriate organization of needed changes in accordance with SSC Standard SSTD-8070-0005-CONFIG.

b. Responsibilities for the use and control of this SSTD and for the review and approval of revisions or cancellation of this SSTD shall be as specified in SSTD-8070-0005-CONFIG and the applicable documents referenced therein.

5.0 GENERAL REQUIREMENTS

5.1 Physical Security

Site and project specific electrical security requirements will be developed with the advice and assistance of the NASA Security Office.

5.2 Environmental, Safety And Health (ES&H)

The safety and health of employees and the public, as well as mitigation of environmental impact, take precedence over function, cost or expediency. ES&H facility performance objectives shall comply with applicable provisions of the latest edition of SCWI-8500-0026-ENV and SPR 8715.1.

5.3 Codes, Standards, And Regulations

The design and installation of electrical systems shall comply with the current edition of NPR 8820.2, NFPA 70, NFPA 780, LPI-175, UL 96, IEEE C2, and the Occupational Safety and Health Act (OSHA) 29 CFR 1910 and 29 CFR 1926. Applicable standards of the American National Standards Institute (ANSI), American Society for Testing and Material (ASTM), Illuminating Engineering Society (IES), National Electrical Manufacturers Association (NEMA), Institute of Electrical and Electronics Engineers (IEEE), Insulated Power Cable Engineers Association (IPCEA), National Fire Protection Association (NFPA), and Underwriters Laboratory (UL) reflect current electrical industry standard practice and should be used for establishing quality of materials and equipment. All of the aforementioned documents shall be applied to all sections of this SSTD, whether cited specifically or not.

5.4 Operation And Maintenance

The design, equipment selection, and construction of the electrical systems shall consider anticipated operation and maintenance requirements as defined by approved requirements document. Apparatus and system connections shall be of simple and straightforward design to facilitate both normal and emergency functions of operating and maintenance personnel. All electrical equipment shall include provisions for lockout devices in accordance with OSHA 29 CFR 1910.147.

Note: To ensure accurate and timely numbering/labeling of facility electrical equipment and update of the Computerized Maintenance Management System (CMMS), all new facility electrical equipment and the CMMS tag numbers of all removed facility electrical equipment, shall be reported to the Synergy Achieving Consolidated Operations and Maintenance (SACOM) Real Property Specialist.

5.5 Drawings And Specifications

a. The approved drawings and specifications are contract documents and shall be prepared to complement each other. Every attempt shall be made to ensure that drawings and specifications are not in conflict.

b. SSC Construction Specifications will be made available at SSC. The designer shall edit the specifications based upon the requirements for each design. The designer is responsible for removing portions of the specifications that do not apply to his or her design and editing the specification to comply with this standard. (Refer to SSTD-8070-0004-CONFIG.) **Note: Specifications are not to be construed as design standards.**

c. Drawings and specifications are to be prepared in accordance with SSTD-8070-0001-CONFIG and SSTD-8070-0002-CONFIG. Standard symbols for electrical drawings are contained in SSTD-8070-0002-CONFIG.

d. Provisions for tag and lockout per OSHA 29 CFR 1910.147 shall be specified in applicable subsections of all construction and procurement specifications.

6.0 ELECTRICAL DESIGN AND CONSTRUCTION GUIDANCE

Electrical loads and requirements shall be estimated for 5-year load projections. Facilities shall be designed accordingly and in compliance with applicable codes, taking into account operation and maintenance requirements.

> **NOTE:** A dedicated electrical equipment room shall be provided in every project, except for modification projects where power can be supplied from an existing electrical equipment room. Avoid installing electrical equipment in places such as hallways and stair landings to provide an unimpeded means of egress as required by NFPA 101. Size electrical equipment rooms and arrange equipment to provide adequate clear space for maintenance, inspection, and repair or replacement. Size the electrical equipment room based on the actual or maximum possible dimensions of all electrical equipment that will be installed in the room. Provide at least one general purpose receptacle in each electrical equipment room.

6.1 Requirements Documents

An approved requirements document is required prior to beginning the technical design process for all electrical designs, including those that are part of a larger design. Incorporate all requirements identified in the latest revision of the requirements document.

For the purposes of this standard, new or revised requirements documents shall be approved by NASA SSC Center Operations, Operations & Maintenance Division and NASA SSC Safety and Mission Assurance (S&MA), the funding organization, the designing organization, the Operating and Maintenance (O&M) organization, and the end user of the facility or system. For the purposes of this standard, requirements documents are not required to be in any specific format.

6.1.1 General Requirements

a. As a minimum, design shall be in accordance with the latest issue of the National Electrical Code (NEC), OSHA 29 CFR 1910, Section 340 of the 42 U.S.C. 6834, and as specified herein or in the requirements document. Incorporate any additional and/or more stringent requirements specified herein or in the requirements document.

b. For all electrical designs that have XFMR ≥125kVA and <240V or XFMR ≥15kVA and ≥240V, permanently installed generators or Motor >50 HP, and all battery banks of 8 or more where the short circuit current is ≥4kADC, perform an arc flash hazard assessment and other design calculations as required by the NASA Project Manager (PM).

   1. An arc flash hazard analysis shall be performed by, or under the direction of, an electrical engineer who has completed formal commercial training in

power system analysis and arc flash hazard analysis and who has significant commercial experience in performing same.

2. Arc flash hazard analyses developed for SSC shall be reviewed and approved by SACOM's electrical engineering lead to be considered delivered and complete.
3. Data shall be submitted to the NASA PM in SKM Power Tools for Windows or other electronic format as approved by the NASA PM.
4. Final approved copies of this data shall be submitted to Central Engineering Files (CEF).
5. All electrical modifications shall comply with SSTD-8070-0138-ELEC.

c. The SSC Fire Department and NASA SSC S&MA shall be invited to participate in all design reviews that include fire protection systems.

d. The SSC High-Voltage System Engineer shall be invited to participate in all design reviews that include the high voltage distribution system.
   1. The SSC High-Voltage System Engineer shall be required to concur with all designs that affect the high-voltage distribution system.
   2. Concurrence shall be provided by signature on drawings and specifications prior to approval and construction.

e. All electrical equipment shall be UL listed.
   - All electrical equipment shall conform to Factory Mutual (FM) standards as applicable.
   - Exceptions shall be approved by the PM.

f. All electrical designs shall provide an updated panel schedule (if affected) with the design package.
   1. The latest panel board schedule can be provided from CEF and should be compared with the panel schedule in the field (if available). If there are differences of a significant nature or no field schedule is available, inform the Contracting Officer's Technical Representative, NASA PM or the FOSC construction monitor for resolution.
   2. Once this work has been completed, the contractor or shops performing the work shall ensure this updated panel schedule is installed in/on the panel board and the panel schedule is returned to CEF.

6.1.2 Drawings

Drawings of existing facilities will be made available at SSC, but they should not be interpreted as "as built" conditions. The designer is responsible for the accuracy of the drawings based on field verification and the latest information available.

6.1.3 Design and Construction Implementation Plan

As a minimum for all projects, a Gantt chart in Microsoft Project format is required. For all projects with a projected design value more than $5,000, an integrated schedule, in Microsoft Project (2013 version) format, is required. This integrated schedule shall include, as a minimum, all electrical tasks from funds request to project completion and activation.

6.1.4 Design and Construction Cost Estimate

Design and construction cost estimates shall be calculated for all electrical projects in sufficient detail to generate a schedule of values that includes, as a minimum, major electrical equipment items, miscellaneous electrical material, and labor.

6.2 Enclosures

All enclosures shall be suitable for the environment and classification, and shall comply with OSHA requirements. Substitutions must be approved by NASA PM.

6.3 Exterior Utility Services

Note: Primary service at SSC is supplied from NASA's overhead distribution system at 13.8 kV, delta configuration. Please refer to SSTD-8070-0083-ELEC for detailed design information. Taps for 13.8 kV primary facility service may be routed underground for aesthetics.

a. For underground primary feeder cable, use single conductors, copper, 15 kV ungrounded, copper tape shielded, 133% insulation level, UL type MV-105 as a minimum with ethylene-propylene rubber (EPR) insulation to include a polyvinyl chloride (PVC) jacket.
   1. Primary circuits shall be sized No. 1/0 or 500 MCM, depending upon the design load requirements. Taped splices are not acceptable at SSC. Underground splices and terminations are not allowed.
   2. Terminations:
      - Shall be above grade; and,
      - Shall land on end point apparatuses, SF_6 switches, or termination cabinets.
      - Stacking dead break terminations is not allowed unless approved by the SSC High Voltage System Engineer.

b. Install primary and secondary feeders in underground concrete-encased ducts. Use 150mm (6-inch) ducts minimum for 500-MCM circuits, and 100mm (4-inch) ducts minimum for 1/0 circuits. Separate underground ducts from steam, condensate, hot water, chilled water lines, and gas lines. Any below ground splices shall be approved by the NASA PM per IEEE 386.

c. Provide pre-cast concrete manholes, if required, with cast-iron covers.
- The manhole unit shall be designed to withstand the dead load, AASHTO H-20 wheel live load, and any horizontal earth pressures imposed by the water table.
- All exterior surfaces and duct bank penetrations of pre-cast manholes shall be sealed to prevent water penetration.
- Minimum dimensions shall be 1800 mm (70 inches) wide by 2400 mm (95 inches) long by 2100 mm (83 inches) deep.

d. If 15 kV switches are required for underground service, they shall be pad-mounted Sulfur Hexafluoride (SF_6) gas insulated, 600-amp size, with IEEE 386 separable connectors with 600 amp apparatus bushings.

e. Lightning arrestors for the 13.8 kV distribution system:
- Shall be metal-oxide type, with a Maximum Continuous Operating Voltage (MCOV) of 8 kV, suitable for application on an ungrounded delta system.
- Lightning arrestors shall comply with IEEE 62.11.

f. For transformer requirements, see Section 6.9 of this standard.

g. Overhead pole lines shall conform to SSC Standards.
- Pre-stressed concrete poles, conforming to ASTM standards, shall be permitted for all main lines.
- Location, accessibility, aesthetics, replacement, and maintenance cost shall be considered in choosing between concrete and wooden poles.
- The NASA PM shall specify the requirement.

g. Primary overhead conductors shall be stranded Aluminum Conductor, Steel Reinforced (ACSR), sized for the anticipated loads plus a minimum 25% growth factor.
- Minimum conductor size shall be 336,400 Circular Mils for main lines, and #2 for taps. Anticipated loads include projected loads for at least five years beyond the construction date.
- Insulators shall be rated for 25 kV minimum.

h. Secondary feeders shall be single conductors, copper, with 600 V insulation.

i. All new electrical services shall be metered, either through existing infrastructure or new metering equipment, for the purposes of utility billing.

6.4 Interior Building Services

a. Locate building service equipment as centrally as possible to shorten branch circuits and achieve economies of construction and operations. Locate electrical equipment in rooms or spaces dedicated exclusively to such equipment.

b. Include a plan and elevations of the electrical room in the contract drawings.
- All required working clearance dimensions shall be indicated on the drawings.
- A note shall be included on the drawing that requires that these dimensions be maintained at all times.

c. Include a requirement to mark the required working space clearances around the equipment with striped yellow border on the floor in the specifications. The location of this border shall be indicated on the contract drawings.

6.5 Equipment Designation

6.5.1 Codes

Designate (code) all electrical equipment with the following designations. Refer to the "Note" in Section 5.4.

Note: All prefix codes listed below shall be suffixed with a letter if the utilization voltage is in excess of 250V or with a number if 250V or less. Example: A 480V or greater motor control center will be coded "MCC-A"; a 208V motor control center will be coded "MCC-1". Suffixes shall be applied in ascending order, if more than one unit per structure. Add suffix IG for isolated ground panel boards. Example: PP-A-IG (480V power panel board with isolated ground).

ATS	Automatic Transfer Switch
BAT	Battery
CHG	Charger (battery)
DIM	Dimmer (lighting)
DP	Distribution Panel
EDP	Emergency Distribution Panelboard
ELP	Emergency Lighting & Appliance Panelboard
EPP	Emergency Power Panelboard
IPC	Instrument Power Conditioner
JB	Junction Box
LP	Lighting & Appliance Panelboard
MCC	Motor Control Center
MCP	Motor Control Panelboard

MDP	Main Distribution Panelboard
MG	Motor-Generator Set
MTS	Manual Transfer Switch
PDC	Panelboard, Direct Current
PP	Power Panelboard
US	Unit Substation
SW	Non-fused Disconnect Switch
SWB	Switchboard
SWG	Switchgear
T	Transformer (do not use for transformers in unit substations or for instrument transformers)
TB	Terminal Box
UPS	Uninterruptible Power Supply
VFD	Variable Frequency Drive
VSD	Variable Speed Drive

6.5.2 Components

Identify motors and their controllers with the equipment of which they are a component. When a separate disconnect switch is used with a motor controller, label the disconnect switch with the mechanical equipment designator.

6.5.3 Code Tags and Name Plates

Identify all electrical equipment with proper code tags and nameplates.

6.5.4 Nameplate Schedule

The designer shall prepare a nameplate schedule for every project. For small projects with few nameplates required, the nameplate schedule may be shown on any appropriate electrical drawing.

- Electrical nameplates shall be furnished and installed in accordance with the designations taken from the nameplate schedule(s).
- The nameplate designation shall include at a minimum the source of power, its characteristics, the load served, and its location.

6.6 Wiring Designations

Wiring designations shall comply with NFPA 70 110.15 and NFPA 70 230.56.

6.6.1 Color Codes for Power Wiring

Conductors size 10 AWG and smaller shall be manufactured with colored insulation, and installed according to the following color codes. For larger conductor sizes that are not normally manufactured with colored insulation, colored tapes for identification are acceptable.

Note: For work in an existing facility, color coding consistent with the existing system shall be used. If the existing system has mixed color codes, use the system shown below. Notify NASA Operations & Maintenance Division of any existing facility that does not comply with the system shown below.

a. For AC circuits, use the following wiring color codes:

Phase	120/208 V	277/480 V
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral	White	White
Ground	Green	Green
Isolated ground	Green with yellow stripe	Green with yellow stripe
Control ground	Green with orange stripe	Green with orange stripe
Instrument ground	Green with blue stripe	Green with blue stripe
Static bleed ground	Green with white stripe	Green with white stripe

b. For DC circuits, use the following wiring color codes: Positive - Red, Negative - Black.

6.6.2 Phasing and Phase Rotation

The standard for all phasing and phase rotation shall be A-B-C clockwise unless the existing system is otherwise.

a. Panel and Switchgear Buses: The proper sequence is A-B-C from left to right, and from top to bottom, front to back (as viewed from front, operating side) of buses, panels, switchgear, etc.

b. On three-phase delta secondary systems, the high-voltage "stinger" leg should be designated B phase and colored according to the appropriate phase-to-neutral voltage.

6.6.3 Terminal Block Labeling

a. All terminal blocks shall be clearly labeled and separated from terminal blocks carrying significantly different and hazardous voltages. For purposes of this requirement, voltages may be grouped less than 50 V, 50 to 250 V, 251 to 600 V, and over 600 V.
   - AC and DC circuits shall be served with different terminal blocks.
   - Terminal blocks with terminal voltage exceeding 250 V shall be dead front.
   - Control circuits and power circuits shall not be served by the same terminal blocks.

b. Any equipment having terminal blocks with voltages greater than 50 V shall be labeled adjacent to the terminal blocks with a yellow label with minimum 4-mm (5/32") black letters stating: "CAUTION - VOLTAGES GREATER THAN 50 VOLTS MAY BE PRESENT ON TERMINALS."

6.7 Conductors

Note: All conductors for general wiring shall comply with OSHA requirements.

a. Perform calculations for conductor sizing with consideration given to voltage drop, temperature de-rating, raceway fill de-rating, and future loading. Provide these calculations to the NASA PM as requested.

b. All conductors shall have UL label and markings required by the NEC.

c. All conductors shall be copper. Aluminum is not acceptable, except for overhead primary distribution.

d. Conductor insulation shall be fire resistant.

e. Ground conductors shall be insulated (green).

f. Conductors No. 10 AWG and smaller shall be 600 V copper, type Heat Resistant Thermoplastic (THHN)/ Moisture and Heat Resistant Thermoplastic (THWN).
- For branch circuit power and lighting circuits No. 10 AWG and smaller, splices and connections shall be made by application of spring tension connectors specifically designed and sized properly for the conductors being spliced, and insulated for 600 V, minimum.
- For all circuits over 250 V, spring tension connectors shall be double wrapped with UL listed electrical tape rated for 600 V, minimum.

g. 600 V conductors No. 8 AWG and larger shall be stranded copper, type THHN/THWN.
- For branch circuit power and lighting circuits No. 8 AWG and larger, splices and connections shall be made by application of crimp-type connectors specifically designed and sized properly for the conductors being spliced, and insulated for 600 V, minimum.
- In areas where crimping is not possible, split lug connectors can be used. Crimp-type connectors shall be double wrapped, first with rubber tape and then with UL listed electrical tape rated for 600 V, minimum.

h. Use No. 12 AWG minimum, 600V insulation, copper conductor for all power wiring and current transformer wiring.

i. If the control wiring is placed in the same conduit with power wiring, 600V insulation is required. For control circuits, splices and connections may be made by the application of crimp-type connectors specifically designed and sized properly for the conductors being spliced, and insulated for the voltage rating of the conductors. Specify termination devices with the same conductor temperature rating. For logic level wiring and wiring from supervisory and annunciation devices to terminal blocks, smaller wire may be used provided it is adequately supported and meets the voltage and current requirements.

j. Multi-conductor cables, cable bundles, and wire pairs shall be labeled on each end with unique designators.
- Wires shall be labeled at each terminal strip using permanently marked heat-shrink labels only.
- Wire and cable labels shall indicate the device located at the opposite end, terminal block, and terminal number.
- All wire and cable designations, terminal block locations, and terminal block assignments shall be documented on Site-wide Operational and Repair Documentation (SORD) drawings or Test Site Drawings per SOI-8080-0007.

k. In designated areas, wiring not in conduit routed in airflow spaces shall be plenum-rated unless approved by NASA PM.

l. All branch circuits shall have a separate neutral and ground.

6.8 Raceways

6.8.1 General

a. Perform raceway fill calculations with consideration to all de-rating required by the NEC NFPA 70. Perform fill calculation and raceway jam ratio calculations.

b. Drawings shall indicate the number of conductors in all conduit runs, wire-way sections, and cable tray sections. Provide these calculations to the NASA PM as requested.

c. Identify conduits, wire-way sections, and cable tray sections and indicate in the drawing the corresponding conductor fill.

d. Specify a requirement in the contract to label all main feeder conduits, all wire-way sections, and all cable tray sections. Labels should also indicate maximum conductor fill.

e. Test facility control systems, data acquisition, data networks, and instrumentation cables shall be separated and not occupy the same raceway with power and other service conductors, unless approved by the E&TD design chief or designee.

f. Provide minimum 100% spare capacity for control and instrumentation raceways, and 200% spare capacity for data network raceways. This spare capacity shall be in the form of spare conduits with pull strings, or spare cable tray capacity. Exceptions to the spare capacities noted above must be documented in an approved requirements document.

g. The use of Teflon tape or other sealants on conduit threads is strictly prohibited at SSC.

h. Field changes require additional calculations to verify that the maximum conductor fill will not be exceeded. Provide these calculations to the NASA PM as requested.

i. Provide adequate grounding on all raceways. Raceways shall not be used as ground conductors. Refer to Section 6.26.

6.8.2 Exterior Raceway Systems

a. Schedule 40 PVC conduit encased in concrete may be used for underground raceways for 13.8 kV systems.

b. Raceways for 13.8 kV service shall be 100 mm (4 inches) for 1/0 conductors serving individual facilities, 150 mm (6 inches) for all lines serving more than one facility, and 150 mm (6 inches) for 500 MCM conductors.

c. The top of the concrete shall be stained red for all 13.8 kV raceways and orange for all other concrete encased duct banks.

d. Generally, specify rigid galvanized steel conduit for installations above ground and concrete encased schedule 40 PVC shall be specified for underground raceway carrying low-voltage systems. However, schedule 80 PVC may be used without concrete for underground low-voltage raceways if not subjected to mechanical injury.

e. Design raceways with the required separations between systems. The required dimensions shall be indicated on the drawing(s).

f. Provide 20% minimum, conduit space and spare conduits for future use in all power conduit duct banks.

g. Use a minimum of 20mm (3/4 inch) size conduit for all exterior installations.

h. Use electrical metallic tubing (EMT) for any exterior installation only when the installation is not subject to extreme weather, mechanical damage or areas classified as hazardous.

i. Install #14 AWG wire rope pull strings in all conduits.

j. Label conduits at both ends with feeder designation numbers.

k. Install color-coded trace tapes above all underground duct banks and conduits, 150mm (6 inches) to 300 mm (12 inches) below the finished grade.

- The color code shall be as follows: Power (all voltages) - Red, all others - Orange.
- The trace tape shall be polyethylene, 75 mm (3 inches) to 150 mm (6 inches) wide, with a metallic tracer formed into the tape.
- The trace tape shall be tied to the conduit it is marking, with the metallic trace extending above ground for ease of identification.

6.8.3 Interior Raceway Systems

a. Specify rigid steel conduit if the installation is subjected to severe mechanical or chemical hazard. Non-metallic conduit may be used in concealed locations allowed by the NEC. Flexible metallic conduit and liquid-tight flexible metal conduit may be used in locations allowed by the NEC. In all other locations, the use of EMT is acceptable as allowed by the NEC.

b. Design raceways with adequate separations between systems. Indicate the required dimensions on the drawing(s). Design adequate space for future growth into the system. Use a minimum of 20mm (3/4 inch) conduit size except for connection to instrument devices where a 15mm (1/2 inch) conduit may be used.

c. Openings around electrical conduit and cable tray penetrations through fire resistance rated walls, partitions, floors, or ceilings shall be fire-stopped using UL-approved materials and methods. Put typical notes in applicable drawings requiring the contractor to have the Construction Manager inspect the openings before and after sealing compounds are poured.

d. Locate conduit stub ups on drawing(s) as well as indicating dimensions from reference point(s) and between stub ups.

e. Install #14 AWG wire rope pull strings in all new conduits.

f. Label conduits at both ends with feeder designation numbers.

g. Conduits shall not be used for supporting any other installations except as permitted by NEC.

h. Transitions between raceway systems, such as conduit to tray, conduit to wire-way, etc., shall be detailed and shown on the drawing(s). Provide adequate ground continuity per NEC for all raceway transitions.

i. Wire-way installations shall be detailed and shown on the drawing(s).

- Wire fill shall comply with the NEC.
- No more than 30 current-carrying conductors shall occupy a wire-way at any point (cross-section).
- Installation of receptacles on wire-ways shall be permitted only if manufacturer's design permits.
- Show mounting details on the drawing(s).

j. Cable tray installation shall be detailed and shown on the drawing(s).
- Tray fill shall be in accordance with the NEC.
- Provide cable tray fill schedules in the drawing(s).

6.8.4 Test Facility Raceway Systems

- All test facility raceways shall be labeled on both ends with unique designations, in accordance with the SORD system.
- All raceway designations and locations shall be documented on SORD drawings.

6.9 Transformers

Note: All transformers shall be installed and properly marked in accordance with OSHA requirements.

6.9.1 Facility Services

- Facility services shall be supplied by 13.8 kV delta - 480/277 V wye, 3-phase, non-PCB liquid-filled transformers.
- Up to 300 kVA may be pole-mounted, 301 kVA and above shall be pad mounted outdoors. Specify 55°C/65°C rise rating with copper windings, primary and secondary surge protection, and manufactured in accordance with IEEE C57 and NEMA standards. Specify loop feed configuration, with IEEE 386 connectors for primary connections to pad mounted transformers.
- Primary Basic Impulse Levels (BIL) rating shall be in accordance with IEEE C57. Design oil containment requirements for transformers according to Factory Mutual recommendations.

6.9.2 Pole Type Transformers

- Pole type distribution transformers (maximum 100 kVA) shall be single-phase, non-PCB liquid-filled, conventional type, 14,400/24,900Y V primary voltage,

480/277 V secondary voltages, with universal taps at 13,800 V, 13,200 V, 12,870 V, and 12,540 V.

- Transformers shall be manufactured in accordance with IEEE C57.12.20.
- Completely Self Protected (CSP) transformers are not acceptable.

6.9.3 Dry Type Transformers

- Dry type secondary distribution transformers shall be used for indoor applications only and only if a liquid filled transformer is not suitable for the specific installation. The use of outdoor type cast coil or encapsulated substation dry type transformers is prohibited at SSC. Exceptions may be considered for some applications, only with prior consultation and approval from the NASA S&MA**,** NASA Center Operations, Operations & Maintenance Division and Project Management Division. If approved, the transformers shall be three-phase, 60 Hertz, fan cooled, 13.8 kV - 480/277 V Delta-Wye, 80°C rise, 110 kV BIL rating.
- **All transformers above 75 kVA shall be manufactured with copper windings.**
- The transformers shall be manufactured and tested in accordance with IEEE C57, NEMA, and IEEE standards.

6.9.4 Metering

See Section 6.28.

6.9.5 General Purpose Transformers

For general purpose dry type transformers for low voltage distribution (15 to 500 kVA), limit the loads on the transformer to 80% maximum of its full load capacity.

- The transformer shall be 3-phase, 60 Hertz, 480 V to 208/120 V Delta-Wye, constructed in accordance with NEMA, ANSI, ASA, and IEEE standards.
- Primary and secondary windings shall be copper.
- Insulation shall be 220°C class.
- Temperature rise shall be 80°C.
- The transformer shall have two 2.5% taps above, and two 2.5% taps below neutral, and shall be 100% tested to meet ANSI/NEMA sound level standards.
- The transformer shall be UL listed.

6.9.6 Non-Linear Loads

a. For non-linear (non-sinusoidal) loads, specify a dry-type distribution transformer specifically designed for non-linear loads such as switching mode power supplies, electronic solid state ballasts, diode and silicon controlled rectifiers, high intensity discharge lighting, variable speed drives, inverters welders, etc.

- Non-linear transformers shall be used when non-linear loads exceed 25% of the transformer rating.
- Where possible, the loads on the transformer shall be limited to 80% (40% non--linear load and 40% linear load) of its maximum full load capacity.
- The transformer shall be 3-phase, 60 Hertz, Delta-Wye, constructed in accordance with NEMA, ANSI, ASA, and IEEE standards.
- Primary and secondary windings shall be copper.
- Insulation shall be 200°C class.
- Temperature rise shall be 80°C.
- The transformer shall have two 2.5% taps above, and two 2.5% taps below neutral.
- The transformer shall be 100% tested to meet ANSI/NEMA sound level standards.
- The minimum K rating shall be K-4 for any transformer with harmonic loads, and K-13 for transformers with non-linear loads totaling 25% or more of the transformer rating.
- The transformer shall be UL 1561 listed.

b. A copper electrostatic shield shall be inserted between the primary and secondary windings to attenuate high frequency harmonics.
   - The secondary conductors shall all be individually insulated, as small in size as possible, and transposed where necessary to keep hysteresis and eddy current losses at the harmonic frequencies to an absolute minimum.
   - The secondary neutral shall be twice the ampacity of the secondary phase conductors.
   - The primary winding conductor shall be of sufficient size to limit the temperature rise to its rated value even with circulating third harmonic currents.

6.9.7 Clearance

Ensure sufficient clearance for access to all transformers.

6.9.8 Spare Growth Capacity

Ensure all new transformers are designed with 20% spare growth capacity. All transformers shall be provided with taps accessible on one side only.

6.10 Motors

The use and procurement of motors is normally initiated by the mechanical engineer or designer. It is the responsibility of the electrical engineer or designer to review the electrical portion of the specification for the motor to ensure compliance with the standards set forth in this section.

a. Specify energy efficient motors. Motor nameplates shall contain efficiency labeling for full-load efficiency with indicated maximum and minimum expected efficiency.

b. Specify a service factor of 1.15.

c. *Specify 480 V, 3-phase, 60 Hertz power input for all motors .56 kW and larger.

d. *Specify 3-phase, 60 Hertz power input for all motors .37 kW and above.

e. *Specify 120 V, 208 V or 240 V, single phase, 60 Hertz power input for all motors less than .37 kW, unless available at 3-phase 208 V or 480 V.

* In the case of smaller motors and/or if this type of power is not readily available, consult with the NASA PM for substitutions.

6.11 Motor Controllers

6.11.1 General

a. Indicating lights shall be provided. They shall be color-coded and labeled to clearly identify the operational mode of the equipment or system. Indicating lights color code shall be as follows:

RED (Stop/Danger/Hazard) denotes a system or component that is energized, running, or closed.

GREEN (Go/Normal/Safe) denotes a system or component that is de-energized, stopped (not running), or open.

AMBER (Caution/Standby/Pending Trouble) denotes a fault condition.

b. Padlocking provisions shall be provided on all devices.

c. Wiring shall be Type 1B.

6.11.2 Motor Control Centers

Generally, if there is a significant number of motors and other 480V loads, a 480V motor control center shall be provided to feed these loads.

a. Motor control centers shall be 480V 3-phase, 3-wire rated at 600 VAC.

b. The horizontal bus, vertical bus, and ground bus shall be plated copper.

c. Combination starters shall be full voltage across the line, circuit breaker type.

d. Circuit breakers shall be 600 VAC rated. Refer to Section 6.11.3 for motor starter requirements.

e. Control voltage shall be 120 VAC. Provide control transformers for each starter.

f. Provide push-to-test indicating lights.

g. Provide a minimum of 10% spare starters and 10% spare spaces for future use.

h. Provide two normally open (N.O.) and two normally closed (N.C.) spare auxiliary contacts for future use.

i. Motor control center shall have a UL label.

j. A housekeeping pad is not required except in areas adjacent to sources of water or any fluid leaks.

k. Provide a level work area in front of the motor control center for ease of handling breakers and draw-out equipment and to meet the NEC requirements for mounting heights of devices.

l. Motor control centers shall be front access only.

m. Specify non-automatic main breaker.

n. Provide phase loss protection.

6.11.3 Motor Starters

a. Specify circuit breaker type across the line voltage combination starters magnetic type with solid state overload protection in each ungrounded phase, with reset, phase loss protection, momentary type start/stop buttons, and push-to-test indicating lights.

b. Starters shall be provided with a fused 120 VAC control transformer for control circuits. Specify fuse blown indicator type fuses.

c. Provide two N.O./N.C. contacts with four 18-gauge wires from all variable frequency drives (VFDs) to safety switch.

6.11.4 Manual Starter

Provide 120 VAC single-phase manual switches for starting single-phase fractional kW motors. Manual switch starters shall be provided with thermal overload protection.

6.11.5 Motor Control Schematic Wiring Diagram

Provide a schematic control diagram for all motors including single-phase motors and instrumentation.

- Instrumentation symbols shall be in accordance with the current Joint Instrument Council (JIC) standards.
- Schematic control diagrams shall be drawn in accordance with the *Facilities Drafting Manual* SSTD-8070-0002-CONFIG.

6.12 Distribution Switchboards

a. Supply interior power requirements from a distribution switchboard that is to be located in the electrical equipment room. The distribution switchboard shall serve as the service entrance equipment.

b. Distribution switchboards used as service entrance equipment shall be specified as such to comply with the NEC and UL requirements for service entrance equipment.

c. Distribution switchboards shall be manufactured and tested in accordance with NEMA, ANSI, IEEE and UL standards.
- Switchboards shall be completely assembled, wired, adjusted and tested at the factory.

d. Distribution switchboards shall be UL listed.

e. Main distribution switchboards shall be 3-phase, 4-wire, 480Y/277V, rated at 600 VAC, if 50% or more of the facility load can be served at that voltage.
- Other distribution switchboards shall be 3-phase, 4-wire, 480Y/277V, rated at 600 VAC or 208Y/120V rated at 240 VAC.

f. Distribution switchboards shall be front accessible only and front aligned.
- All parts, including bus connections that require adjustment and regular maintenance, shall be accessible from the front only.
- Provide hinged covers/doors.

g. Limit the switchboard width to the minimum for ease of maintenance and access.

h. All busses rated 225 amps and higher, including the phase bus, the neutral bus, and the ground bus, shall be plated copper.
- All other bus material shall be approved by the NASA PM.
- Neutral bus shall be fully rated.

i. All circuit breakers shall be molded case type or drawout type.

- All circuit breakers shall be 600 VAC rated and shall have solid state trip and provision for padlocking.
- Handle extensions shall be provided as required.

j. A housekeeping pad is not required except in areas adjacent to sources of water and other fluid leaks.

k. Provide a level work area in front of the switchboard for ease of handling breakers and draw-out equipment and to NEC requirements for mounting heights of devices.

l. Ensure sufficient clearance for access to all switchboards.

m. Main breakers shall be used when required by the NEC.

n. Provide transient voltage surge suppression per NFPA 70 (NEC) and NFPA 780.

o. All breakers greater than 1000 amps shall have ground fault monitoring.

6.13 Panelboards (Light And Appliance)

a. Panelboards shall be 208Y/120-V, 3-phase, 4-wires or 480Y/277V, 3-phase, 4-wires.

b. All busses rated 225 amps or higher, including the phase bus, the neutral bus, and the ground bus, shall be plated copper.
- All other bus material shall be approved by the NASA PM. Neutral bus shall be fully rated.

c. Each branch circuit shall have its own dedicated neutral.

d. Limit the number of branch circuit poles to 42 maximum.

e. Circuit breakers for use on a 208Y/120V panelboard shall be 240V, AC rated, molded case type and circuit breakers for use on a 480Y/277V panelboard shall be 600V, AC rated, molded case type.
- Main breaker and identified feeder breakers other than breakers for lighting and receptacle loads shall have padlocking provisions.

f. Specify hinged panelboard trim front construction with breaker door hinged and secured with keyed handle, and main cover hinged on one side and secured with screws on the other.

g. Provide 20% growth capacity in each panelboard for future loads in addition to loads identified during design. Provide 50% of the growth capacity provided above for single pole breaker spaces in each panelboard in addition to loads identified during design.

h. Locate panelboards close to the center of the load area so that branch circuits can be limited to a maximum distance of approximately 45m (150 feet) for 277/480 V systems, and 25m (80 feet) for 120/208 V systems.

i. Maintain and indicate on the drawing(s) all required working space clearance dimensions. A note on the drawing shall be included, requiring that these dimensions shall be maintained at all times and requiring the contractor to mark on the floor the boundaries of the working clearance with striped yellow border.

j. Mount panelboards so that the distance from the floor to the handle of the highest breaker will not be more than 2m (6 feet, 7 inches).

k. Provide engraved laminated plastic nameplates on the exterior of panel-boards indicating name, voltage, phase, source, etc. Include a requirement in the contract specifications for the contractor to provide and install the nameplates in accordance with the nameplate schedule. Panelboards served by uninterrupted power supplies (UPSs) shall be clearly marked with minimum 12.7mm (1/2-inch) high white lettering on black background.

l. Provide a typed circuit directory in each panelboard. Include a requirement in the contract specifications for the contractor to provide and place a typed circuit directory inside the panel door.
   - The circuit directory shall include the panel and circuit number of the source of power.
   - All panelboard circuits shall be numbered so that the odd numbered circuits are on the left, and the even numbered circuits are on the right.
   - Multiple circuits shall be numbered using all space designations that the breaker occupies.
   - (**Note:** All circuit directory information and panel information is to be collected, updated, and disseminated through a central Electrical Breaker Panel database maintained by CEF.)

m. Balance the loads between all phases of each panelboard, upon completion of installation or modification.

n. Panelboards shall be UL listed.

o. Single-phase panelboards are generally unacceptable and shall not be used unless approved by the NASA PM.

6.14 Panelboards For Instrument, Electronics And Computer Loads

a. Power to instrument, electronics, and computer loads shall be fed from dedicated panel boards with an isolated ground system.
   - These panel boards shall be designated as special power panelboards (SPP).

b. Instrument power panelboards shall be 208Y/120V, 3-phase, 6-wire systems with an insulated isolated ground bus (IG) and an un-insulated equipment ground bus (EG).

c. SPP shall be UL listed.

d. Phase bus, neutral bus, equipment ground bus, and isolated ground bus shall be plated copper if the bus rating is 225 amps or higher.
   - All other bus material shall be approved by the NASA PM. Neutral bus shall be fully rated.

e. Limit the number of branch circuit poles to 42 maximum.

f. Circuit breakers shall be AC rated bolt-on type.
   - Main breaker shall have padlocking provisions.

g. Loads shall be fed from the special power panelboard through isolated ground type receptacles.

h. Isolated ground type receptacle shall be standard NEMA grade with an orange triangle.
i. Limit the number of isolated ground type receptacles to two per circuit.

j. Locate special power panelboards close to the center of the load area so that branch circuits can be limited to a maximum distance of approximately 25m (80 feet) on 120/208 V systems.

k. Maintain and indicate on the drawing(s) all required working space clearance dimensions. Include a note in the drawing requiring that these dimensions shall be maintained at all times and a note requiring the contractor to mark on the floor the boundaries of the working space clearance with striped yellow border.

l. Mount panel boards so that distance from the floor to the handle of the highest breaker will not be more than 2m (6 feet, 7 inches).

m. Provide engraved laminated plastic nameplates on the exterior of panel boards indicating name, voltage, phase, source, etc. Panel boards served by UPSs shall be clearly marked with minimum 12.7mm (1/2-inch) high white lettering on black background.

n. Provide a typed circuit directory in each panel board in accordance with section 6.13-l.

o. Specify hinged panel board trim front construction with breaker door hinged and secured with keyed handle, and main cover hinged on one side and secured with screws on the other.

p. Provide 20% growth capacity in each panel board for future loads in addition to loads identified during design. Provide 50% of the growth capacity provided above for single pole breaker spaces in each panel board for future use.

q. Balance the loads between all phases in each panel board.

r. Install a surge suppressor for each instrument power panel per LPI-175 and NFPA 780. Non-use shall be approved by the NASA PM.

s. Single-phase panel boards are generally unacceptable and shall not be used unless approved by the NASA PM.

6.15 Receptacles

6.15.1 120V Receptacles

a. Specify specification grade, NEMA type 5-20R, 2-pole, 3-wire grounding, 20-amp, 125 VAC UL listed duplex receptacles for 120 V outlet general use. Label receptacles for voltages above 120 V with the correct voltage and number of phases.

b. Provide 120V duplex receptacles for general use in all areas in accordance with NEC and as required by the user.

c. Provide 20-amp dedicated outlets and circuit(s) for custodial use in all hallways at 9m (30-foot) stations.

d. Design for a maximum of six duplex receptacles per 20-amp circuit.

e. Provide ground-fault circuit-interrupter (GFCI) type receptacles, per NFPA 70, in kitchen areas, bathroom areas, shower areas, vending areas, and all outdoor locations, including on roofs where roof mounted equipment may require maintenance.

f. Provide GFCI protection for drinking water fountains.

g. GFCI receptacles shall be accessible.

6.15.2 208V, 3-Phase Receptacles

Provide NEMA locking type, standard configuration with grounding 250 VAC single receptacles, as required by the user.

6.15.3 480V, 3-Phase Welding Receptacles

NEMA locking type, standard configuration with grounding, 600 VAC welding receptacle shall be provided, as required by the user.

6.15.4 Special Receptacles

Special receptacles required by the customers shall be identified in the requirements document.

6.15.5 UPS

Receptacles served by UPSs shall be manufactured with blue colored body materials.

6.16 Cover Plates

Construction specifications and drawings shall specify that the contractor attach on the cover plate of each receptacle a label indicating the panel board and the circuit number from which the receptacle is fed.

6.17 Switches

Specify heavy-duty specification-grade 20-amp 120-277 VAC quiet switches for general use.

6.18 Disconnect Switches

a. Provide local non-fusible safety switches or circuit breakers for all motor loads. Locate safety disconnect switch so that it is within reach of the operator at all times. For elevator loads, the disconnecting means shall be an enclosed externally operable circuit breaker capable of being locked in the open position.

b. Provide heavy-duty type, UL listed, kW rated disconnect switches. Disconnect switches shall meet NEMA specifications.

c. Provide padlocking provisions for all safety switches.

d. Label all safety devices to comply with NEC and OSHA requirements. Include load being served and the source of power (panel and circuit).

6.19 Exterior Lighting

a. Use high-efficiency lighting fixtures for all general-purpose exterior lighting except as specified in section 6.19-g.

b. A centralized lighting control system for energy management shall be considered on facilities provided with remote control/monitoring interface to the site-wide EMCS building automation system.

c. Control exterior lighting by means of photocells, and remote control/monitoring interface shall be provided to the site-wide EMCS building automation system.

d. Lighting contactors are to be used for control of parking lot lighting only.

e. Mount light fixtures on building walls where appropriate. Fixture shall be located so that glare is not directed toward any guard station.

f. The type of fixtures and mounting shall be similar to existing lighting in adjacent buildings or areas (if applicable).

g. Perform lighting calculations. Refer to SSTD-8070-0085-EMCS for lighting design details.

h. Lighting for video recording shall be designed to provide the correct color temperature and intensity for the video recording equipment specified by the requirements document.

i. Exterior lighting shall be fed by 277Vor 480V circuits.

j. All exterior lighting shall be UL-listed and approved for that location.

k. All exterior lighting shall be rated per the hazardous area classification.

6.20 Interior Lighting

a. Use high-efficiency lighting fixtures for all general-purpose interior lighting.

b. Perform lighting calculations. Refer to SSTD-8070-0085-EMCS. Higher illumination levels for any area shall be approved by the NASA PM.

c. Switch lighting by areas or by zones.

d. Provide motion-activated lighting for normally unoccupied areas, except mechanical equipment rooms and restrooms.

e. A centralized lighting control system for energy management shall be considered on facilities provided with remote control/monitoring interface to the site-wide EMCS building automation system.

f. Coordinate lighting design with architectural ceiling grid design and sprinkler system, and with the user's functional needs and the type of equipment that will be used (e.g., computers, etc.).

g. Interior lighting shall be fed by 277V or 480V circuits.

h. Electronic ballast shall be less than 10% total harmonic distortion.

6.21 Emergency And Exit Lighting

a. Locate emergency and exit lights shall be located in accordance with the *Life Safety Code* NFPA 101.

b. Refer to SSTD-8070-0085-EMCS for lighting design details.

c. All new or replacement exit lights shall be green light emitting diode (LED) type or self-luminous type.

d. Emergency lighting systems shall provide a reasonable means of performing required operational tests per NFPA 101.

e. Emergency lights shall be able to perform an automatic test for not less than 30 seconds and a diagnostic routine not less than once every 30 days.
- Failures shall be indicated through a status indicator, independent from maintenance personnel.
- Continuous status of that test shall be held in the unit until the next test cycle.

6.22 Standby Generators And Transfer Switches

a. Provide a quick disconnect on the outside of the facility for a portable generator connection when required by the customer, or when deemed prudent based upon the function performed by the facility.

b. Provide a transfer switch for all generator circuits. An automatic transfer switch is preferred for all permanent generator installations. A manual transfer switch is required

for all portable generator installations. Each transfer switch shall be equipped with a maintenance bypass switch.

c. New designs shall incorporate a standby bus and wiring for critical loads in the facility.

d. For all automatic start generator installations, provide the following remote indications to the Energy Management and Control System (EMCS) operator as a minimum:
- Output breaker position;
- Bypass switch/breaker position;
- Hand-off automatic (HOA) switch position;
- Water jacket low temperature alarm;
- Low oil pressure alarm;
- ATS switch position; and,
- Generator running indication.

6.23 Uninterruptible Power Supplies (UPS)

a. The need for a UPS, as well as the size and style (on-line or standby) of the UPS, shall be justified in the requirements document prior to design.

b. UPSs shall be properly sized for the expected loads and the required power delivery period. Typically, UPS units are sized to provide a minimum of 30 minutes run time at full rated load.
- All UPS units sized 3 kVA and larger shall incorporate 3-phase power where available.
- UPSs shall be designed with a 20% growth factor.

c. All permanently installed UPS installations shall incorporate maintenance bypass switching and safety measures.

d. All permanently installed UPS systems serving loads in areas protected by sprinkler systems shall have shunt trip provisions connected to the facility fire alarm control panel to completely de-energize the loads in the sprinkled area or a disconnect means at the principle exit(s).
- The shunt trip or disconnects shall disconnect all AC and DC power sources from the UPS system.
- Exceptions to this requirement per NEC 1999 are UPS systems serving integrated electrical systems in which orderly shutdown is necessary to prevent equipment damage or personnel injury due to sudden loss of electrical power, and UPS systems less than 750 volt-amperes.

e. All UPS battery systems shall be tested for acceptance at the manufacturer's facility, or upon initial installation at a specific discharge rate and for a duration relating to the purchase specification requirements.
   - In the absence of purchase specification requirements, acceptance tests shall be made to validate the manufacturer's rating.

f. For critical UPS installations requiring continuous remote monitoring (e.g., EMCS), interface provisions shall be provided in the equipment procurement. Preferred information for remote monitoring are output breaker position, bypass switch/breaker position, power failure, DC bus voltage, low battery alarm, ATS switch position, and UPS online indication.

g. As a minimum, all UPSs shall have a power failure (on battery reserve) and a low battery alarm/indicator. Alarm silence capability is recommended.

h. Provide isolation transformers and/or filters to ensure that harmonics produced by the UPS do not feed back into the power supply.

i. The battery cabinet or rack on all UPS units sized 3 kVA or larger shall provide at least 20 cm (8 inches) of clearance from the battery posts to the level above it for easy access to posts and straps during maintenance.

j. Where battery cells are contained in a battery cabinet, the cabinet shall provide adequate space for maintenance personnel. Sufficient space is needed to allow maintenance personnel access to each individual cell for voltage and inter-cell resistance measurements without having shutdown or disassembly of the battery string.

6.24 Telecommunications

a. Provide telecommunications closets in new facilities. For work in existing facilities, extend telecommunications services from existing telecommunications closets. Provide lighting with a dedicated switch for the telecommunications closet.

b. Install a minimum of two 100mm (4 inches) conduits from the telecommunications closet to the nearest telecommunications manhole.

c. Install a 1200mm (48 inches) by 2400mm (96 inches) by 20mm (3/4 inch) fire-retardant plywood telecommunications backboard in the telecommunications closet. Provide two dedicated 120 VAC circuits for convenience power at the telecommunications backboard. Provide a telecommunications ground plate at the telecommunications backboard. Bond ground plate to the building single point ground electrode by means of a No. 6 AWG stranded copper ground conductor.

d. Provide a minimum of one outlet box or tele-power pole for telecommunications outlet(s) in each office or work station. Route a 20mm (3/4 inch) minimum conduit with a pull string back to the telecommunications backboard.

e. Telecommunications wiring shall be properly supported and hung per NFPA 70.

6.25 Fire Alarms

Fire detection for facilities shall conform to NFPA 72 and NASA Standard 8719.11.

6.26 Grounding

a. Design the grounding system in accordance with the NFPA 70 (NEC Article 250) and as specified in this section.

b. The earth ground resistance of the power grounding system shall range between 1 to 5 ohms.

c. Install a ground grid underneath the substation or a grounding counterpoise around the substation, supplemented by electrolytic ground rod(s). Bond the substation grounding system to the building grounding electrode system at the service entrance by means of a #4/0 ground conductor.

d. Install a 25mm (1 inch) by 1m (3 feet) by 6mm (1/4 inch) copper grounding bar at the service entrance for single-point grounding, with #4/0 ground conductor to the nearest ground rod on the building grounding electrode system.

e. Install an insulated (green) ground conductor in all conduits and other raceway systems for equipment grounding. The raceway system shall not be used as a grounding conductor.

f. Insulated grounding conductors shall be sized in accordance with NEC.

g. Provide a grounding system diagram.

h. Show all equipment grounding bond connections in the grounding plan drawing or in the power plan drawing(s), by symbol or by note.

i. Use exothermic connections for all underground and inaccessible bonding connections.

j. Provide a minimum of one ground test point well in each corner of the facility for facilities with a perimeter greater than 150 feet. For facilities 150 feet or less in perimeter, provide one ground test point well.

k. Ground all metallic items in the electrical systems.

l. Use 19mm (3/4 inch) by 3m (10 foot) copper-clad ground rods at a minimum. Grounding to underground pipes is not acceptable.

m. Ground resistance tests shall use the fall-of-potential method, unless the physical layout of the facility prohibits practical application of this method. In such cases, alternate methods may be applied to determine resistance to true earth ground, providing these alternate methods are approved by the NASA PM.
- Tests shall not be performed less than 48 hours after last rainfall.
- Single rod electrodes shall not exceed 10 ohms.
- The resistance to true ground for lightning protection systems shall be 5 ohms maximum.

n. Earth ground resistance measurements shall be made for all new construction per IEEE Std. 81, at the recommended intervals during construction period.

o. Raised flooring shall be connected to the facility grounding electrode system.

p. For test area specific grounding regulations, refer to SREF-8060-0001.

6.27 Lightning Protection

a. A lightning protection system shall be required for all structures over 16m (50 feet) in height, or any facility with high value equipment, or as required per NASA-STD-8719.12.

b. Extend the lightning protection to any building addition if the addition is not within the lightning protection zone coverage of the existing facility.

c. Design and install the lightning protection system in accordance with NFPA 780, LPI-175, and NASA-STD-8719.12 for facilities in which explosives are used or stored, and as specified in this section.

d. Install a lightning protection perimeter grounding system**,** #4/0 minimum conductor size, at a minimum distance of 60 mm (24 inches) from the foundation wall to a maximum of 1000mm (40 inches) and at a minimum depth of 600mm (24 inches) below grade. Bond the counterpoise to the building grounding electrode system at the service entrance and at each corner structure steel column.

e. Specify UL and LPI approved materials. Copper is strongly suggested; but aluminum may be used if material to be installed on existing surfaces is made of aluminum or if copper is not suitable for the environment. All down conductors must be made of copper unless the environment prevents the use.

f. Route down conductors along surface of exterior wall. Through-the-roof connectors are not acceptable.

g. The resistance between the air-terminals and the counterpoise ring shall be 10 milli-ohms or less.

h. Tests of bond connection resistance shall be required only upon initiation of a discrepancy report or D&CR.
- Bond connections shall be less than or equal to 1 milli-ohm.

i. Any point on the facility ground network shall be 100 milli-ohms or less.
- The facility structure itself shall be tested at strategic points.

j. Testing of the resistance of the counterpoise to true earth ground shall be verified using the "fall of potential" method per MIL-HDBK-419A, Volume I, where practical.
- This resistance shall be 5 ohms or less.

k. Testing of the resistance-to-counterpoise values of the components of the lightning protection system, including the air terminals, shall be performed at no greater than 21-month intervals.

l. For facilities in which explosives are used or stored, testing of the resistance-to-counterpoise values of the components of the lightning protection system, including the air terminals, shall be performed at no greater than 12-month intervals

m. The meter to be used to perform testing of the air terminals and facility ground network connections shall be of sufficient resolution to determine accurate readings of 10 milli-ohms or less.

n. Visual inspection of the Lightning Protection System shall occur on an annual basis per NFPA 780. Any discrepancies should be identified on a D&CR.

o. The Lightning Protection System shall be certified per UL-96A and LPI-175.

p. For new facilities, specify a requirement that material manufacturers furnish shop drawings showing lightning protection system, installation details, and list of materials. The contractor shall provide UL certification.

q. For existing facilities, inspection of the lightning protection system shall be the responsibility of the maintenance contractor.
- The contractor shall be required to correct all deficiencies promptly.
- Once the system has passed inspection, the maintenance contractor will arrange for an LPI certification.

r. For test area specific lightning regulations, refer to SREF-8060-0001.

6.28 Metering

a. All facilities shall be provided with a combination kWh/Demand meter on the secondary side of each distribution transformer.
- Additionally, all facilities shall be provided with an EMCS building automation system digital electrical energy monitor capable of remote readings at the EMCS Central Station Operators Servers/Consoles.

b. Metering equipment shall be suitable for outdoor installation, and normally be mounted on the exterior of the low voltage compartment of pad mount transformers. Provide a 25mm (1 inch) conduit hub in the meter base into the low-voltage compartment for meter connections. Provide conduit knockouts in the meter base for future connection of EMCS conduits and wiring.

c. Metering facilities shall consist of three metering accuracy current transformers, approved kilowatt-hour meter, approved test switch, and all interconnected wiring.

d. Current transformers shall be placed around low-voltage bushings.
- Current transformers shall be equal to General Electric type JAB-O.
- Meter shall contain output terminals for external kW and kWh monitoring connected to K, Y, and Z output terminals.

e. New meter installations shall be form 9S.
- Exceptions shall be approved by the NASA PM.

f. Meter shall be mounted in a 20-amp, transformer rated, 13-terminal meter socket, ringless, with an approved 10-pole test switch.

g. Meter socket shall be a Milbank Type S7449-XL or approved equal.

h. Test switches shall be Superior Switchboard and Devices Type MP713-FMS-2975, or approved equal.
- The test switch shall be rewired to accept a Ferraz Shawmut fuse holder, catalog number USBCC3, or NASA-approved equal, for 480 VAC inputs.

- On the test switch, the CT test switches shall be relocated to the left of the fuse holder.
- The fuse holder shall be mounted on the right side to a DIN rail attached to the test switch. See Attachment.

i. EMCS tie-in requirements for digital energy monitoring.

- The EMCS Digital Electrical Energy Monitor (DEM) shall be the Siemens DEM Series 2000 or approved equal.
- The DEM shall be configured with split-core instrument grade current transformers (CT's) in a single package unit with a set of three (3) each CT's for three-phase consumption.
- All processing and communications shall be self-contained within the main CT.
- The DEM Series 2000 or approved equal shall be capable of reading/measuring and calculating the following at a minimum: KWH Consumption, KW Demand, KVA Apparent Power (3-Phase Total), KVAR Reactive Power (3-Phase Total), Power Factor Effective, Voltage (Line to Line 3-Phase Average), Line to Neutral 3-Phase Average, Phase A to B, Phase B to C, Phase A to C, Phase A to Neutral, Phase B to Neutral, Phase C to Neutral, Current (3-Phase Average Phase A, Phase B & Phase C.
- The DEM Series 2000 or approved equal shall be capable of communicating and being configured/interfaced to the Siemens APOGEE Building Automation System as a Floor Level Network (FLN) microprocessor on the P-1 communication trunk.
- The DEM shall be installed and configured on the load side main/secondary of the main building transformer "prior" to any electrical load serving the facility to which it is serving.

6.29 Sewage Lift Stations

All electrical work, including pump motors and controls, which is installed in sewage lift stations shall meet the requirements of Article 500 of the NEC for Class 1, Division 1 or 2, Group D locations.

- Electrical power status (normal/alarm) and high water level indication (normal/alarm) shall be provided to the site-wide building automation system for remote monitoring capabilities.

6.30 DC Power Systems

DC power systems provide an independent source of power for control systems.

- The DC supply shall be sufficiently sized for the total connected load.
- DC supply batteries shall be sized to provide a minimum of 30 minutes run time at full rated load of the DC supply. Additional time may be required to adequately secure the facility in the event of a commercial power loss.

7.0 RECORDS AND FORMS

Records and forms required by the procedures of this standard shall be maintained in accordance with SPR 1440.1. Records dispositioned as Quality Records are identified on the SSC Records Index electronic database on the SSC Home Page. All forms are assumed to be the latest edition unless otherwise specified and may be obtained from the SSC Electronic Forms repository on the SSC Home Page or from the NASA SSC Forms Management Officer.

APPENDIX A - ACRONYMS, ABBREVIATIONS AND DEFINITIONS

A.1 Acronyms and Abbreviations

Note: Acronyms for Equipment Designator Codes are listed in Section 6.5.1.

AASHTO	American Association of State Highway and Transportation Officials
AC	Alternating Current
ACSR	Aluminum Conductor, Steel Reinforced
amp	ampere
ANSI	American National Standards Institute
ASA	American Standards Institute
ASTM	American Society for Testing and Material
ATS	Automatic Transfer Switch
AWG	American Wire Gauge
BIL	Basic Impulse Levels
°C	Degrees Centigrade
CEF	Central Engineering Files
CFR	Code of Federal Regulations
CMMS	Computerized Maintenance Management System
CSP	Completely Self-Protected
DC	Direct Current
D&CR	Discrepancy Report
EG	Equipment Ground
EMCS	Energy Management and Control System
EMI	Electromagnetic Interface
EMT	Electrical Metallic Tubing
EPR	Ethylene-Propylene Rubber
ERD	Environmental Resources Document
E&SD	Engineering and Science Directorate (NASA)
ES&H	Environmental, Safety and Health

E&TD	Engineering and Test Directorate
FM	Factory Mutual
GFCI	Ground-Fault Circuit-Interrupter
HOA	Hand-off Automatic
IEEE	Institute of Electrical and Electronic Engineers
IES	Illumination Engineering Handbook
IG	Isolated Ground
IPCEA	Insulated Power Cable Engineers Association
JIC	Joint Instrument Council
K	Harmonics designator
k	kilo
kV	kilovolt
kVA	kilovoltampere
kW	kilowatt
kWh	kilowatt hour
LED	Light Emitting Diode
LPI	Lightning Protection Institute
m	meter
MIL	Military
MCC	Motor Control Center
MCM	Thousand Circular Mils
MCOV	Maximum Continuous Operating Voltage
mm	millimeter
MM&C	Measurement, Monitor, and Control Systems
MV	megavolt
MVA	megavoltampere
NASA	National Aeronautics and Space Administration
N.C.	Normally Closed
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
N.O.	Normally Open
NPR	NASA Procedural Requirements
NSTS	National Space Transportation System

O&M	Operating and Maintenance
OSHA	Occupational Safety and Health Act
PCB	Polychlorinated Biphenyl
PM	Project Manager
PVC	Polyvinyl Chloride
S&MA	Safety and Mission Assurance
SACOM	Synergy Achieving Consolidated Operations and Maintenance
SF_6	Sulfur Hexafluoride
SKM	name of manufacturer of "Power Tools for Windows"
SORD	Site-wide Operational and Repair Documentation
SPP	Special Power Panelboard
SPR	Stennis Procedural Requirements
SSC	Stennis Space Center
SSLP	Stennis System Level Procedure
SSTD	SSC Standard
STD	Standard
THHN	Heat Resistant Thermoplastic
THWN	Moisture and Heat Resistant Thermoplastic
UL	Underwriter's Laboratory
UPS	Uninterrupted Power Supply
U.S.C.	United States Code
V	volt
VAC	Volts Alternating Current
VFD	Variable Frequency Drive
Y	connection type (3-phase)

A.2 Definitions

High Voltage: 600 volts and higher

Low Voltage: below 600 volts

ATTACHMENT: EMI 09B307-05, E-502